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A COMBINED FOCUSSING AND SAFETY STAGE FOR USE IN MICROMETRY WITH HIGH POWERS.

By C. M. Vorce, F. R. M. S., Cleveland, O.

This device consists of two perforated brass plates, the upper bearing two spring clips to hold the slide, and the lower having springs lifting the upper plate and also a micrometer screw at each end passing up freely through the upper plate, which is depressed by milled nuts on the micrometer screws, opposed by the lifting-springs of the lower plate. All this is shown in the sectional view of the focussing stage (*fig. 1*), and needs no further description, as the action of the parts is obvious. The object of the device is to move the slide instead of the objective in focussing, in order that when making measurements by projecting the image on a screen the distance of the screen from the focal point of the objective may remain absolutely unchanged, which is necessary to avoid the objection that the power has been changed by changing this distance. In micrometry it is essential to avoid, so far as possible, every theoretical as well as every practical source of error, even if it should be too minute to affect, appreciably, the result. And especially is this true of micrometry applied to determine, judicially, important questions. In micrometry there are, with all the ordinary appliances, some theoretical sources of error, which, although in most cases so minute as to be, in their effect upon the accuracy of the result, practically *nil*, are sufficient to afford pretexts for objection on the part of those who

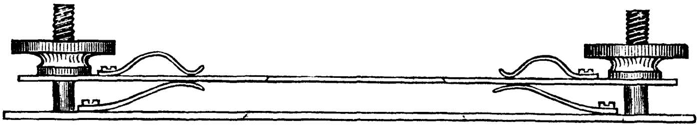
Fig. 1.

seek to magnify every defect to be found in the work of others whose results are not agreeable to the views or wishes of those who so object. The identity of results by different methods, and correlation of tests, may often show a given method to be practically exact, yet, if any theoretical objection can be raised against it, it may often be so treated as to completely discredit results that are in point of fact accurate and reliable, and, unfortunately, the less scrupulous the party who thus seeks to discredit such results, the greater the success likely to attend his efforts.

Therefore, it is a matter of some importance that any microscopist who may be called upon to make micrometic measurements to determine any given point should adopt such methods as are the least open to objection on account of inherent theoretical errors, for it is obviously important that his work, if correct, shall stand as authoritative and not be discarded, and there is, as experience has shown, much less danger that erroneous work will be accepted as authoritative than that really correct work will be laid open to doubt. This is well illustrated by the case of the stage micrometer. Every microscopist knows that if any one should succeed in ruling a micrometer *absolutely exact and correct*, one in which the spaces were all exactly equal and of exactly the value designed, yet it would be months and probably years before its accuracy would cease to be doubted and disputed, and every possible point which theory could raise involved in its production, and by any possibility susceptible of causing error in the result, would be urged against its reliability. In forensic micrometry, by which term I mean all cases in which micrometry is applied to afford evidence of some fact involved in the judicial determination of a question by the courts, it is especially important that no unnecessary chance should be afforded any one to cast doubt upon the accuracy of the methods employed or upon the validity of the result obtained. At the best, enough will be done by one side or the other to raise suspicion and doubt as to the reliability of the micrometry, even with the narrowest ground to work upon.

The foregoing, with other considerations, induced me to adopt the following method of micrometry for high powers: Instead of using extremely high-power objectives to gain great magnification, tube length, as advocated by Beale, is employed, and the image is viewed direct, *i. e.*, without magnification by eye-piece, the method having been suggested in part by former experience in the micrometry of blood, and in part by experience in photo-micrography. A base-board is provided, some four or five feet long, at one end of which the lamp is placed enclosed in a light-tight box. A magic lantern answers admirably for illumination, connecting its condenser tube with the stage of the microscope by means of a light-tight sleeve. The microscope is placed horizontally with amplifier in place and tube as short as possible and internally blackened to avoid reflection. A movable vertical screen, faced with white card-board or glass, is adjusted on the base-board at such distance from the microscope as is found suitable, but need not, ordinarily, exceed two feet, and is clamped in place when adjusted. The focussing stage is adjusted on the microscope stage, clamped in place, and a micrometer is put in place and focussed, the image being observed on the screen. When the desired power is gained by moving the screen along the base-board it is clamped in place and the lines of the micrometer, as seen on the screen, are traced by means of a ruler and pen on the face of the screen, and by the use of dividers the spaces may be further subdivided. In the measurements to be made the microscope and screen are not moved in the least, nor even touched, except to turn the screws of the mechanical stage. The micrometer is removed by pressing down the top plate of the focussing stage, the slide containing the objects to be measured is substituted and the plate, on being released, brings the slide into focus, if it is of the same thickness as the micrometer, if not, it is brought into focus by the focussing screws of the focussing stage. When focussed, the image on the screen is viewed and the measurement read off and noted as the slide is passed along by the movement of the mechanical stage. If, owing to uneven thickness or curvature of the slide or cover, the object begins to pass out of focus, it is focussed by means of the screws of the focussing stage. The operator sits, ordinarily, near the screen, working the stage with the left hand and noting the measurements with the right: the milled nuts of the focussing stage are easily reached, and the work proceeds rapidly; although two operators, one to note down the measurements as called off by the other, and occasionally changing places, facilitate the work. The arrangement of apparatus is shown in *fig. 2.*

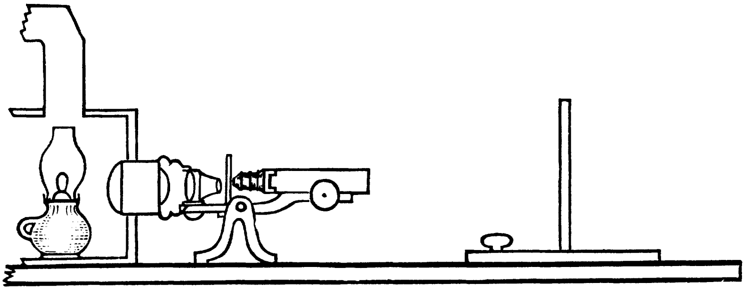

Fig. 2.

It is obvious that with this device the power employed is always the same, when once adjusted, and enlargement up to 5,000 diameters may be obtained. The micrometer eye-piece, where the body is moved by the fine adjustment, is also practically unchanging in power, but cannot easily afford the same amount of magnification, unless with unusually high-power objectives whose short working distance usually precludes their use with tube lengths sufficient to give so great amplification.

A very convenient method of using the focussing stage in micrometry is to so adjust the screen that .001 inch of the stage micrometer exactly equals 1 inch of the paper scales used by architects and divided into hundredths of inches; by pasting one of these scales across the screen and bringing the micrometer lines (of .001 inch) to coincide with the inch lines of the scales, as shown in *fig. 3*, and clamping the screen in that position, a scale upon the screen is obtained reading to $\frac{1}{100000}$ inch, which is far finer than can ordinarily be utilized, although by sunlight the striæ of some diatoms, such as *F. saxonica* and *A. pellucida*, will puzzle the eyesight in attempting to count their striation by means of the scale.

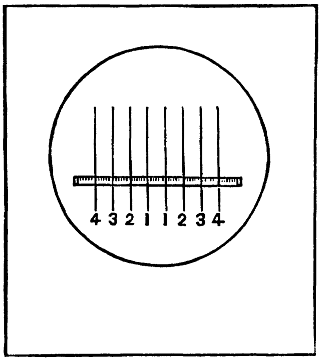

Fig. 3.

An incidental feature of this focussing stage is that it will not allow the slide or cover to be broken in focussing, and is, therefore, a safety stage as well.

In making measurements by this method the same spaces of the scale should be used for every measurement, and, preferably, the central ones, thus removing any question as to variation of power or aberrations in the extreme edges of the field. Thus, if the objects measured are about 1½ or 2 divisions of the scale, and two are in the field at once, do not read the dimensions and record them as they stand, but bring first one of the objects to the central line and read from that, and note the measurement; then bring the other object to the *same side* of the central line, read and record as before: both are then measured by the same part of the scale to the extent of the smaller.